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TITLE: Methods and apparatus for ultrasound image quantification

Application Filing Date (1):  
20000106Detailed Description Text (22):

Referring now to FIG. 11, the F-mode processing unit 107 is shown in detail. A demodulator 150 divides the echo signals into in-phase (I) and quadrature (Q) components, as known in the art. A/D converters 152, 154 convert the I and Q analog signals into digital signals. High pass filters 156, 158 remove wall or clutter from the digital signals. When tissue movement is imaged, the high pass filters 156, 158 may be bypassed. An auto-correlation unit 160 computes real and imaginary signals as a function of the auto-correlation of the I and Q filtered signals, as known in the art. A zero (0) to one (1) sample lag is used, and the resulting signals are referred to as the auto-correlation values R(0), R(1).sub.r, R(1).sub.i. The R(0), R(1).sub.r, R(1).sub.i signals represent Doppler data. As an alternative embodiment, the Doppler data is acquired according to the time shift techniques described by Bonnefous in U.S. Pat. No. 4,928,698.

Detailed Description Text (33):

Referring to both FIGS. 1 and 15, the image plane data in buffers 123, 412, and 414, along with any other image plane data, typically comprises the identity of pixels or spatial locations corresponding to particular areas of a body. The image plane data is divided into frames of image plane data. Each frame of image plane data contains data acquired from the body at a particular time. Each of the buffers 123, 412, 414 is divided into sections for storing frames of the different types of image plane data, such as B-mode intensity, Doppler energy, Doppler variance, or Doppler velocity. For any particular type of parameter, values for each spatial location are stored in buffers 123, 412, and 414.

Detailed Description Text (44):

Referring to FIGS. 1 and 15, once the region of interest 131 is selected by the user, the microprocessor 127, 420 determines the spatial location address for each pixel within the region of interest 131. In the embodiment of FIG. 1, the address information is stored in the microprocessor 127. In the embodiment of FIG. 15, the address information is stored in the region Id buffer within the buffers 412, 414.

Detailed Description Text (57):

Once the velocity direction angle for each spatial location in the region of interest 131 is assigned, microprocessor 127 obtains Doppler velocity image plane data from buffer 123. The microprocessor 127 then corrects the Doppler velocity image plane data in accordance with a velocity correction angle. The velocity correction angle at any point in the region of interest 131 is the difference between the Doppler line angle and the velocity direction angle at that point. At each point (X.sub.i, Y.sub.i) in the region of interest 131, the Doppler line angle in the display raster XY coordinate space is given by  $\arctan((X_{\text{sub.i}} - X_{\text{sub.apex}}) / (Y_{\text{sub.i}} - Y_{\text{sub.apex}}))$  where (X.sub.apex, Y.sub.apex) are the display coordinates of the apex of the scan format. The velocity value for each location is then

divided by the cosine of the velocity correction angle.

Detailed Description Text (58):

The velocity values from the Doppler velocity image plane data are also corrected in accordance with a line dependent direction angle. Where the ultrasound scan lines are in the linear or steered linear format, the ultrasound lines are all parallel and at a constant angle to the region of interest 131, and no line dependent correction is made. However, in the sector, VECTOR.RTM. and curved linear array formats, angle correction is further dependent on the Doppler line angle. The angle correction is adjusted as function of the difference of each scan line angle from the user entered velocity direction angle.

Detailed Description Text (97):

Other higher order quantities are conveniently calculated using the bin data of histogram 200. A waveform or curve of the bin data of histogram 200 is created as a function of the bin ultrasound values. The waveform represents the weight or number of occurrences of a particular value as a function of the various bin ultrasound values. Various quantities are derived from the waveform. For example, the standard deviation of the waveform is calculated. As another example, the linear standard deviation is readily available from the histogram 200 after converting the bin ultrasound values to the linear scale.

Detailed Description Text (98):

A waveform of the bin data of histogram 200 as a function of bin ultrasound values in the log scale is also created by microprocessor 127. From the waveform of the histogram 200 in the log scale, a log weighted average or log weighted standard deviation is calculated. Using appropriate reverse log compression and the bin data of histogram 200, a variety of quantitative values and waveforms are calculated.

Detailed Description Text (162):

As an example of combination or comparison, two regions of interest 131 in a person's liver are selected with input from the operator. The image plane data from the two regions of interest 131 are compared to determine the relative amount of perfusion at a certain time. For example, the surface integral of energy is calculated for each region of interest 131. Each surface integral provides a measure of perfusion. A ratio of the two surface integrals is created. The relative amount of perfusion is indicative of an infarction. The ratio function based on values in the linear scale is equivalent to the difference function based on values in a log scale.

Detailed Description Text (164):

As another example, image plane data for one region of interest 131 acquired at a first time is compared with image plane data for another region of interest 131 acquired at a different time. Thus, image plane data from one region of interest is used as a constant for comparison or combination with a second region of interest 131. The portion of the body represented by the second region of interest 131 may be operated on or subject to an injection of some substance, such as a contrast agent. The time difference is seconds, hours or days apart.

Detailed Description Text (173):

A ratiometric comparison tends to cancel out differences due to gain, angle dependence, level of fluid and other differences to provide more accurate results. Further, any differences between the settings of the ultrasound system 100 or 400 while acquiring echo signals, such as differing gain, frequency, transmit power or bandwidth, are preferably corrected prior to any calculations. These differences are available since the ultrasound system 100 or 400 uses the gain, frequency, transmit power and bandwidth to obtain the image plane data. The frequency and bandwidth are scaled, and the gain and transmit power are logarithmically adjusted.